Damage control resuscitation for massive hemorrhage

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**Abstract** Hemorrhage is the second most common cause of death among trauma patients and almost half of the deaths occur within 24 hours after arrival. Damage control resuscitation is a new paradigm for patients with massive bleeding. It consists of permissive hypotension, hemostatic resuscitation and transfusion strategies, and damage control surgery. Permissive hypotension seems to have better results before the bleeding is controlled. The strategy of fluid resuscitation is minimizing crystalloid infusion and increasing early transfusion with a high ratio of fresh frozen plasma to packed red cells. Damage control surgery is done when the patient’s condition is unfit for definitive surgery. Hemorrhage and contamination control with temporary abdominal closure is performed before transferring the patients to intensive care unit and the operating room for a permanent laparotomy.

Key words: Shock; Hemorrhage; Resuscitation

Hemorrhage causes about 30% to 40% of trauma death, which is the second most common cause of trauma death following traumatic brain injury.1,2 Massive blood loss is usually defined as loss of entire blood volume within 24 hours or loss of 50% of blood volume within 3 hours.

The management of hemorrhagic shock has evolved over the decades followed by new development in basic sciences and clinical trial evidence. Damage control resuscitation (DCR) is first introduced in military medicine and then is adapted for civilian trauma to deal with massive hemorrhage. DCR consists of three main strategies: permissive hypotension, hemostatic resuscitation and transfusion strategies, and damage control surgery. It aims to reduce bleeding and optimize coagulation3 and is especially beneficial for patients with massive hemorrhage.4

Permissive hypotension

Permissive hypotension is one component of DCR, which is put forward because higher blood pressure may displace the clot or “pop the clot.”5 In practice it requires holding intravenous fluid, and maintaining a lower blood pressure until hemorrhage is controlled.3 A landmark article published in 1994 by Bickell et al5 was conducted on 598 hypotensive patients with penetrated torsos. The result showed survival advantage in the delayed resuscitation group which received intravenous fluid resuscitation after the hemorrhage had been controlled. Patients in an immediate resuscitation group required longer hospital stays (14 days vs. 11 days, P=0.006). However, a systematic review6 published in 2003 showed non-convincing results against early and large-volume resuscitation.

There is still no consensus on an accepted blood pressure for permissive hypotension. A study7 used a mean arterial pressure (MAP) of 60 mmHg as the endpoint of hypotensive resuscitation in swine. This study showed that increasing MAP to 75 mmHg was associated with high blood loss and diminished splanchnic blood flow while delayed fluid resuscitation decreased blood loss but failed to reestablish splanchnic blood flow. Several studies conducted on human used a target blood pressure.

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Morrison et al. investigated patients with blunt and penetrating trauma who had experienced in-hospital hypotension, and found that the group with a target MAP of 50 mmHg had less blood products transfusion when compared with the group with a target MAP of 65 mmHg. The results also showed that the lower blood pressure group had less coagulopathy and lower mortality in the first 24 hours postoperatively. Although this study intended to recruit both blunt and penetrating patients, a majority of them suffered a penetrating trauma.

In military trauma care, palpable radial pulse and normal mental status were reported as the endpoint of resuscitation. Systolic blood pressure of 70-80 mmHg as a threshold value of resuscitation has also been proposed. An European guideline also recommends a target systolic blood pressure of 80-100 mmHg until bleeding is controlled in patients without traumatic brain injury, but this recommendation lacks strong evidence.

**Hemostatic resuscitation and transfusion strategies**

Hemostatic resuscitation and transfusion strategies aim to minimize coagulopathy. A better understanding of the mechanism of coagulopathy makes the paradigm of resuscitation changed accordingly.

Traditionally, coagulopathy in trauma is thought to be a secondary effect from hemodilution after massive fluid resuscitation. Later studies demonstrated that coagulopathy occurred before the patients received massive intravenous fluids, probably due to endogenous systemic anticoagulant and hyperfibrinolysis. Thromboelastography or thromboelastometry are new tools which help to diagnose acute traumatic coagulopathy more quickly as well as provide more details than the traditional international normalized ratio. In patients with hyperfibrinolysis, administration of tranexemic acid reduces the risk of mortality (14.5% vs. 16%, P=0.0035) but requires administration within 3 hours post injury.

Since the late 1970s, crystalloid- and plasma-based resuscitation has replaced whole blood-based resuscitation. There is evidence that transfusion of plasma-free red blood cell products is associated with coagulopathy. Many studies demonstrated that a high ratio of fresh frozen plasma (FFP) to packed red cells (PRC) had survival advantage. An investigation conducted on 246 patients at an army combat support hospital found that patients with a high ratio of FFP:PRC (1:1.4) had a lower mortality rate than those receiving intermediate ratio (1:2.5) and low ratio (1:8, 19%, 34% and 65%, respectively, P<0.001). Other civilians studies also found that patients transfused with a high ratio of FFP:PRC had better survival rates than those with a low ratio; however, those are retrospective studies.

A prospective observational study by Holcomb et al demonstrated that the patients who received blood transfusions early with high ratio of FFP:PRC had decreased 6-hour mortality even though the subsequent risk of death at day 30 was not associated with ratio of plasma or platelet to PRC.

Although the resuscitation with early transfusion with a high ratio of FFP:PRC seems beneficial, it has not been proved by a prospective randomized control trial. An ongoing prospective trail (the Pragmatic Randomized Optimum Platelet and Plasma Ratios) is funded by National Institutes of Health and the United States Department of Defense.

With resuscitation with high ratios of plasma and platelet to PRC proposed, resuscitation by minimizing crystalloid infusion has been initiated simultaneously. Normal saline and lactated Ringer solution were the most commonly used in resuscitation. Evidence later revealed that administration of crystalloid during the initial resuscitation was associated with complications such as multi-organ dysfunction, abdominal compartment syndrome, and coagulopathy.

In summary, hemostatic resuscitation and transfusion strategies have been moved toward minimizing crystalloid infusion for resuscitation and using a high ratio of blood products. However, which ratio is the best for patients needs to be investigated with randomized controlled trials.

**Damage control surgery**

Damage control surgery is an initial control of hemorrhage and contamination followed by
intraperitoneal packing and rapid closure as well as resuscitation in the intensive care unit before transferring patients to the operating room for a definitive laparotomy. A landmark article was published in 1993 by Rotondo et al who found that patients in the damage control group had a higher survival rate than the permanent laparotomy group (77% vs. 11%, P<0.02). In the past decades, the damage control laparotomy has been refined several times before formation of the current model. The core concept of the evolution is to identify the patients who need the damage control laparotomy. Damage control resuscitation is added in the process of damage control laparotomy, and the techniques for abdominal wall closure have been changed over time. Currently, the indications for damage control surgery are mainly physiological changes such as presence of hypothermia, acidosis and coagulopathy.

Conclusion

DCR is a strategy to resuscitate patients with massive blood loss. Permissive hypotension is useful for patients with penetrating trauma. However, it is still debated in patients with blunt trauma combined with head injury. In hemostatic resuscitation and transfusion strategies, hyperfibrinolysis has been considered more in resuscitation and Tranexamic acid is recommended in all trauma patients with significant hemorrhage. Early transfusion with a high ratio of plasma to PRC and minimization of crystalloid usage are also recommended. However, the exact ratio of plasma to PRC needs to be investigated. Damage control surgery has developed until a consensus is reached. The future research will be focused on temporary abdominal closure. For example, a new technique should be proposed to increase success rate of fascial closure.

REFERENCES


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